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Northwest Firefighters Mortality Study: 1945 1989

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Northwest Firefighters Mortality Study: 1945-1989

Final Report

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Executive Summary

In the last two decades there has been increasing concern by firefighter organizations and occupational health professionals that exposure among firefighters to fire smoke could lead to an increased risk of cancer, lung disease, and heart disease. In 1984 we began a retrospective mortality study of Seattle firefighters. Later, funding was received from the Federal Emergency Management Agency (Contract EME-88-K-0176), U.S. Fire Administration, through a cooperative agreement to extend the study to the fire departments of Partland, Tacoma, Bellevue, and Kent and to collect data on police from the same cities as a comparison group. This is a report of the results of the expanded mortality study with fallow-up through the end of 1989.

The study population consists of 4546 men who were employed by the cities of Seattle, Portland, Tacoma, Bellevue, and Kent for at least one year in fire combat positions between 1944 and 1979. In addition to comparing the study population to U.S. white male rates, comparisons were also made between Seattle, Portland, and Tacoma firefighters and police officers from the same cities who had been employed for at least a year between 1941 and 1979.

Between 1945 and 1989, 1173 death occurred in the study population and 1155 death certificates (98%) were collected. As might be expected, our results are consistent with a strong healthy worker effect; mortality due to all causes (standardized mortality ratio (SMR) = 0.81), ischemic heart disease (SMR = 0.82), and many other non-malignant diseases were less than expected based upon U.S. white male rates. However, our results suggest that 30 years after they were first employed firefighters may be at excess risk of emphysema (SMR = 1.4, 95% confidence interval (CI) = 0.9-2.2) and diseases of the arteries, veins and pulmonary circulation (SMR = 1.3, 95% CI = 1.0-1.8).

The risks of dying from all cancers (SMR = 0.95) and from lung cancer (SMR = 0.93) were approximately the same as would be expected. Excesses of cancers of the brain (SMR = 1.9, 95% CI = 1.1-3.2) and lymphatic and hematopoetic tissues (SMR = 1.3, 95%

CI = 0.9-1-8) were observed. The risk of lymphatic and hematopoetic cancers was greatest for men with at least 30 years of fire combat (exposed) employment (SMR=2.1, 95% CI = 1.1-3.6), especially for leukemia (SMR = 2.6, 95% CI = 1.0-5.4). The results for brain cancer did not follow a pattern of increasing risk with increasing duration of exposed employment, but 11 of 17 cases occurred in men at least 30 years after their first employment as a firefighter (SMR=2.5, 95% CI = 1.3-4.5).

Our results support the findings of increased risk of brain and lymphatic and hematopoetic cancers observed in previous studies of firefighters and earlier analyses of mortality of this cohort. Our results also suggest that firefighting may increase the risk of some types of lung and circulatory diseases.

Background

In the last two decades there has been increasing concern by firefighter organizations and occupational health professionals that exposure among firefighters to fire smoke could lead to an increased risk of cancer, lung disease, and heart disease. Retrospective cohort mortality studies have been conducted for firefighters from Toronto 1921-1953 (l), Boston 1915-1975 (2), Los Angeles 1940-1980 (3), Western Australia 1939-1978 (4), Buffalo 1950-1979 (5), and San Francisco 1940-1982 (6). Proportionate mortality studies from New Jersey 1974-1980 (7) and Boston 1975-86 (8) and a cancer incidence study from Denmark 1970-1980 (9) have also been performed and additional data are available from studies which analyze vital records by occupation (10-17).

A more recent concern about the inhalation of smoke is the increasing use of synthetic materials in both the structures and interiors of buildings which has increased the complexity and toxicity of exposures. Firefighters are potentially exposed to a number of suspected or known carcinogens. Benzene and polycyclic aromatic hydrocarbons are likely encountered at most fires while other, less common, exposures may include aromatic amines, polychlorinated biphenyls's, chlorinated dioxins, vinyl chloride, and acrylonitrile (18-27). Other hazardous exposures include diesel emissions from fire fighting equipment (28), asbestos from clean-up operations (and historically from protective equipment), and many other chemicals from commercial or industrial fires.

Cohort studies of firefighters have found them to be at approximately the same risk of death due to cancer (all sites) as the general population. However, most studies have identified excesses of cancer at some specific sites, although the results have been far from consistent. The most commonly identified sites of excess risk have been the colon or rectum (4,5,8,10,11,14), the central nervous system (3-5,12,15), the lymphatic and hematopoietic tissues (4.7,12,13,16,17), the skin (7,8,16), and the bladder (5,16). Only one cohort study has identified an excess of lung cancer in firefighters (9).

An excess risk of non-malignant heart and respiratory disease is also plausible given firefighter exposures. Many respiratory irritants, such as hydrogen chloride, nitrogen dioxides, isocyanates, and acrolein, are commonly present in smoke (20-22,27,28). There is also some evidence of respiratory dysfunction after acute high exposures (29-32) although studies designed to look at chronic effects have had mixed results (33-39). An increased risk of cardiovascular disease due to intense physical and psychological stress after periods of inactivity or exposure carbon monoxide or toxic gases is also plausible (40-42). However, most studies have found firefighters to be at the same or lower risk than the general population for both heart and lung disease.

Traditionally general population rates have been used as the reference in mortality studies of occupational cohorts. A major bias introduced by using general population rates has been termed the “healthy worker effect.” This can be considered as a confounding effect arising primarily out of the health status needed to acquire and retain employment (43-47). An additional gain relative to the “non-worker” may arise from the benefits of employment which are closely related to socioeconomic status and access to health care (at least in the United States). This bias exercises a particularly strong effect when examining death due to some non-malignant diseases, especially those which have a long period of symptoms and possible impairment prior to death that may either prevent gaining or require leaving employment. In many ways firefighters, with their strict physical entry requirements and relatively good employment benefits, typify a population one would expect to have a strong healthy worker effect and this may in part account for the low risks of both heart and respiratory disease observed in most studies of firefighters. However, earlier analyses of the Northwest Firefighters Study (48) and one other study which used police, an occupation with similar entrance criteria, as a reference population (7) found evidence that firefighters are at increased risk of respiratory disease. In addition, internal analyses of the Seattle firefighters cohort (49) found that the risk of heart disease increased with duration of employment.

In 1984 the Seattle Fire Pension Board funded the Harborview Occupational Medicine Program of the University of Washington to perform a retrospective mortality study of Seattle firefighters (49). The study was performed with the cooperation of the Pension Board, Fire Department, and Seattle Fire Fighters Union Local 27. In 1985 funding was received from the Federal Emergency Management Agency (FEMA), U.S. Fire Administration to extend the study to the fire departments of Portland, Tacoma, Bellevue, and Kent and to collect data on police from the same cities as a comparison group. Police were chosen as a reference population to help control for confounding from the healthy worker effect. This is a report of the results of the expanded mortality study with follow-up through the end of 1989.

Methods

The study population consists of all men who were employed as firefighters for at least one year between 1944 and 1979 by the cities of Seattle (WA), Portland (OR), Tacoma (WA), Bellevue (WA), and Kent (WA). Women were excluded from the study because they began employment as firefighters in 1970's and would thus contribute little to a study of mortality. Years of active duty in positions involving fire combat was used as a measure of smoke exposure. Seattle, Portland, Bellevue, and Kent Fire Department records were reviewed and no exposure was assigned for years spent in administrative duties or support services. Because Tacoma lacked the necessary records, years of employment as a sworn firefighter was used as a surrogate for fire combat employment.

Vital status follow-up and collection of death certificates were performed using information from pension board and fire department records, the death records of Washington and Oregon, the records of the Washington and Oregon Motor Vehicle Departments, and the National Death Index (50). Individuals who were lost to follow-up were only considered at risk until the date they were last known to be alive. Individuals lost to follow-up subsequent to 1978 were assumed to be alive if no death was identified through the National Death Index.

Standardized mortality ratio's (SMR's) relative to U.S. white males were calculated using the microcomputer version of the Occupational Mortality Analysis Program (OCMAP) developed by the University of Pittsburgh (51). Reference rates for U.S. white males were obtained from the National Institute for Occupational Safety and Health (52). White male rates were used because the vast majority of firefighters from the cities studied were Caucasian and department records did not include information on race. Confidence intervals were calculated using a Poisson distribution.

In addition to U.S. males, police were used as a reference population. Comparisons were made between firefighters from Seattle, Portland, and Tacoma and police officers from the same cities who had been employed for at least a year between 1944 and 1979. The fire and police departments of the cities of Portland and Tacoma use the same pension boards which facilitated the collection of comparable data. Unfortunately, complete historical records were not available from either the Seattle Police Department or Pension Board. Therefore, Seattle Police Academy records were used to identify all graduates between 1944 and 1978 for inclusion in the comparison cohort. Incidence density ratios (IDR's) for firefighters relative to police were standardized by 5 year age group and time periods and test based confidence intervals were calculated (53).

Results

A summary of vital status ascertainment, death certificate collection, and person years of follow-up as of January 1st. 1990 is displayed in Table 1. Complete follow-up was achieved for 98% of the 4546 firefighters. Between 1945 and 1989, 1173 death occurred and 1155 death certificates (98%) were collected. The comparison cohort consisted of 3676 police officers and complete follow-up information was attained for 3599 (98%).

During the follow-up period 714 police deaths were identified and 703 death certificates (98%) were collected.

The number of observed deaths and SMR's for major causes of death relative to U.S. white males are displayed for Seattle, Portland, and all cities combined in Table 2. Table 3 presents the IDR's for firefighters relative to the police cohort. The table also lists the number of police deaths observed and the SMR's for police relative to U.S. white male rates. These results are given for all cities for causes of death of a priori interest, including those observed to be in excess in earlier analyses of this cohort or in other studies. The results for all firefighters versus U.S. white males are presented by duration of exposed employment in Table 4, by years since first employment in Table 6, and by age at risk in Table 8. The results for Seattle, Portland, and Tacoma firefighters versus police from the same cities are presented in Tables 5, 7, and 9 by the same three stratification variables. Hodgkin's disease is excluded from the police comparison tables because no cases were observed among police.

The risk of death due to any cause among firefighters was less than expected compared to the general population (SMR = 0.80, 95% confidence interval (CI) = 0.76-0.85). This was due to a lower than expected risk of most types of non-malignant diseases. The risk of death appears to increase with both age and years since first employment and approached that of all U.S. white males for individuals over the age of 65 (SMR = 0.97). Firefighters also had a somewhat lower risk of death than police officers (IDR = 0.87, 95% CI = 0.79-0.95).

The cohort as a whole had approximately the same number of cancers that would be expected based on U.S. white male rates (SMR = 0.95). However, firefighters under the age of 40 had an SMR of 140 due primarily to a greater than expected number of brain cancers (SMR = 3.52) and lymphatic and hematopoietic malignancies (SMR = 1.69). The excess observed for cancers is in contrast to the deficit observed for all causes (SMR =0.59) or a11 non-cancer causes of death (SMR = 0.49).

An excess of cancers of the brain was observed (SMR = 1.93, 95% CI = 1.13-3.10) based upon 17 cases. There was no clear relationship with duration of exposure or years since first employment although 11 brain cancers occurred among firefighters at ieast 30 years after they were first hired (SMR = 2.53, 95% CI = 1.26-4.53). When compared with police the IDR for brain cancer was 1.54 (95% CI = 0.7-3.6) and increased to 3.04 (95% CI = 1.0-9.6) for at least 30 years after first employment.

While the exposure and latency patterns did not exhibit a clear trend, the risk of lymphatic and hematopoietic cancers was elevated for men with at least 30 years of fire combat employment (SMR = 2.05, 05% CI = 1.06-3.59), especially for leukemia (SMR = 2.60, 95% CI = 1.04-5.35). The risk of all lymphatic and hematopoietic cancers and leukemia were also elevated for police with SMR'S of 1.22 and 1.56, respectively. However, the risk of leukemia in firefighters with 30 years of exposed employment remained elevated when compared with police (IDR = 1.80, 95% CI = 0.6-5.4) while the risk of all lymphatic and hematopoietic cancers did nor (IDR = 1.14, 95% CI = 0.5-2.6).

The only other notable excess of cancer was for the prostate (SMR = 1.33, 95% CI = 0.90-1.90) which was also elevated relative to the police (IDR = 1.43, 95% CI = 0.7-2.9). The risk of dying from lung cancer (SMR = 0.93) was approximately the same as would be expected based on U.S. white male rates and was similar when compared to police (IDR = 0.94). The risk for most other cancer sites, including the colon, rectal, or skin, was also similar to that of U.S. white males, although the risk of colon cancer was somewhat elevated relative to police (IDR = 1.58). The only notable cancer deficits were for cancer of the bladder (SMR = 0.11, 95% CI = 0.0-0.62) and kidney (SMR = 0.27, 95% CI = 0.03-0.97).

The risks of all heart disease and ischemic heart disease were less than expected when compared with U.S. rates with SMR's of 0.79 and 0.82, respectively. The same was true when firefighters were compared with police with IDR's of 0.86 and 0.88, respectively. The only category of cardiovascular disease which was elevated relative to U.S. rates was diseases of the arteries, veins, and pulmonary circulation with an SMR of 1.23 (95%

CI = 0.91-1.63). The risk was particularly elevated among firefighters with at least 30 years of exposed employment (SMR = 1.99, 95% CI = 1.29-2.94). While the risk was reduced relative to police (IDR = 0.91) it remained elevated among long-term firefighters (IDR = 1.47, 95% CI = 0.8-2.9).

The risk of non-malignant respiratory disease was less than expected relative to U.S. rates (SMR = 0.89, 95% CI = 0.71-1.11) although the risks of chronic obstructive pulmonary disease (COPD) (SMR = 1.00) and asthma (SMR = 1.06) were similar to expected and the risk of emphysema was somewhat elevated (SMR= 1.18, 95% CI = 0.72-1.82). The risk of emphysema was highest among individuals employed for lo-19 (SMR = 1.80) and 20-29 years (SMR = 1.35) and among those at least 30 years since first employment (SMR = 1.39). The risk of lung disease in firefighters was slightly elevated relative to police (IDR = 1.11, 95% CI = 0.71-1.73) while the risk of emphysema was somewhat higher (IDR = 1.45, 95% CI = 0.54-1.69). Firefighters over the age of 65 were at slightly higher risk of death due to respiratory disease than both U.S. white males (SMR = 1.16) and police (IDR = 1.27).

Table 1: Status as of January 1, 1990 and Years of Follow-Up

Status	**Seattle**	**Portland**	**Tacoma**	**Bellevue & Kent**	**Total (%)**
Currently Employed	610	458	217	77	1,362 (30%)
Retired	782	396	239	7	1,424 (31%)
Other Alive	309	94	22	61	486 (11%)
Deceased	**516**	510	143	4	1,173 (26%)
Certificates Collected	506	502	143	4	1,155(98%)*
Unknown Status	64	24	11	2	101 (2%)
Total	2281	1482	632	151	4,546
Years of Follow-Up	64,048	41,077	17,350	2,699	125,174

* Percent of Death Certificates Collected

Table 2. Northwest U.S. Firetighter Mortality by City: 1945-1989

Cause of Death	Seattle Deaths	Seattle SMR	Seattle 95% CI	Portland Deaths	Portland SMR	Portland 95% CI	All Cities Deaths	All Cities SMR	All Cities 95% CI
All Causes	516	0.74	0.68-0.80	510	0.94	0.86-1.03	1173	0.81	0.76-0.86
All Cancers	144	0.97	0.81-1.14	115	1.03	0.85-1.24	291	0.95	0.85-1.07
Buccal Cavity and Pharynx	1	0.24	0.01-1.31	5	1.54	0.50-3.60	7	0.80	0.32-1.65
Digestive Cancers	37	0.91	0.64-1.26	28	0.87	0.58-1.26	73	0.86	0.68-1.08
Esophagus	1	0.28	0.01-1.56	3	1.11	0.23-3.24	6	0.82	0.30-1.79
Stomach	9	1.28	0.59-2.44	7	1.15	0.46-2.37	16	1.06	0.61-1.72
Intestine	10	0.72	0.35-1.33	10	0.95	0.45-1.74	24	0.84	0.54-1.25
Rectum	2	0.50	0.06- 1.81	5	1.50	0.49-3.50	8	0.95	0.41-1.86
Pancreas	11	1.13	0.71-2.59	3	0.51	0.11-1.50	15	0.95	0.53-1.56
Billary Passages & Liver	5	2.05	0.67-4.78	1	0.52	0.01-2.90	6	1.18	0.43-2.57
Respiratory Cancers	51	0.98	0.73-1.29	34	0.91	0.63-1.27	98	0.93	0.75-1.13
Larynx	1	0.48	0.01-2.69	1	0.63	0.02-351	2	0.47	0.06-1.69
Trachea, Bronchus & Lung	47	0.95	0.70-1.26	33	0.93	0.64-1.31	93	0.93	0.75-1.14
Prostate	16	1.50	0.86-2.43	11	1.28	0.64-2.28	30	1.33	0.90-1.90
Kidney	1	0.27	0.01-1.53	1	0.37	0.01-2.06	2	0.27	0.03-0.97
Bladder & Other Urinary	1	0.23	0.01-1.31	0	0.00	0.00-1.07	1	0.11	0.00-0.62
Other & Unspecified Cancers	16	0.87	0.50-1.41	21	1.58	0.98-2.41	40	1.07	0.76-1.46
Skill	4	1.29	0.35-3.29	2	0.92	0.11-3.34	6	0.96	0.35-2.10
Drain and Nervous System	5	1.13	0.37-2.64	10	3.30	1.58-6.07	17	1.93	1.13-3.10
Lymphatic & Hacmatopoietic Cancer	18	1.28	0.76-2.02	15	1.48	0.83-2.44	37	1.30	0.91-1.79
Lymphosarcoma & Reticulosarcoma	2	0.82	0.10-2.98	3	1.65	0.34-1.82	7	1.41	0.57-2.90
Hodgin's Disease	1	0.69	0.02-3.85	2	2.00	0.24-7.22	3	1.04	0.22-3.04
Leukemia & Aleukemia	8	1.37	0.59-2.69	6	1.38	0.51-3.01	15	1.25	0.70-2.07
Other Lymphatic & Hematopoietic	7	1.61	0.65-3.33	4	1.34	0.37-3.43	12	1.38	0.72-2.42
Unspeclfied Nervous System Tumors	1	1.09	0.03-6.12	0	0.00	0.00-5.67	2	1.09	0.13-3.93
Diabetes Mellitus	5	0.50	0.16-1.17	1	0.13	0.00-0.71	7	0.34	0.14-0.70
Mental & Personality Disorders	3	0.70	0.11-2.03	4	1.36	0.37-3.48	7	0.81	0.33-1.67
Nervous System Disease	5	0.71	0.23-1.65	2	0.40	0.05-1.44	11	0.77	0.38-1.37
Heart Disease	200	0.71	0.62-0.82	206	0.92	0.80-1.06	463	0.79	0.72-0.86
Rheumatic Heart Disease	2	0.36	0.04-1.29	9	2.03	0.93-3.86	12	1.03	0.53-1.80
Ischemic Heart Disease	164	0.71	0.60-0.83	178	0.96	0.83-1.11	396	0.82	0.74-0.90
Chronic Disease of the Endocardium	3	1.53	0.32-4.40	1	0.61	0.02-3.39	4	0.96	0.26-2.44
Hypertension with Heart Disease	6	0.74	0.27-1.61	4	0.51	0.14-1.30	10	0.55	0.26-1.01
Other Heart Disease	22	0.79	0.50-1.20	12	0.61	0.32-1.07	36	0.64	0.45-0.89
Other Circulatory Disease	56	0.87	0.66-1.13	62	1.14	0.87-1.46	1.31	0.96	0.80-1.13
Hypertension without Heart Disease	3	1.34	0.28-3.92	0	0.00	0.00-1.91	4	0.83	0.23-2.13
Cerebrovascular Disease	31	0.72	0.49-1.02	37	0.98	0.69-1.35	79	0.85	0.67-1.05
Arteries, Veins & Pulmonary Circulation	22	1.18	0.74-1.79	25	1.68	1.09-2.48	48	1.23	0.91-1.63
Tuberculostis	0	0.00	0.00-0.85	0	0.00	0.00-0.92	0	0.00	0.00-0.39
Respiratory Disease	33	0.75	0.51-1.05	32	0.94	0.65-1.33	82	0.89	0.71-1.11
Acute Upper Respiratory Infection	2	7.31	0.89-26.4	0	0.00	0.00-17.4	2	3.52	0.43-12.7
Pneumonia	10	0.66	0.31-1.20	8	0.64	0.28-1.27	22	0.68	0.43-1.03
Emphysema	7	0.86	0.35-1.78	10	1.58	0.76-2.91	20	1.18	0.72-1.82
Asthma	2	1.54	0.19-5.56	1	0.85	0.02-4.74	3	1.06	0.22-3.09
COPD & Other Respiratory Disease	11	0.67	0.34-1.21	13	1.14	0.61-1.95	33	1.00	0.69-1.41
Digestive Diseases	17	0.52	0.30-0.83	22	0.89	0.56-1.35	47	0.70	0.51-0.93
Accidents	33	0.73	0.50-1.02	30	0.98	0.66-1.40	73	0.82	0.64-1.02
Transportation Accidents	16	0.64	0.36-1.01	14	0.87	0.47-1.45	35	0.72	0.50-0.99
Accidental Poisonings	4	1.97	0.54-5.05	2	1.56	0.19-5.64	6	1.51	0.55-3.28
Accidental Falls	6	1.18	0.43-2.56	5	1.22	0.40-2.84	12	1.12	0.58-1.96
Other Accidents	5	0.38	0.12-0.88	8	0.92	0.40-1.81	16	0.61	0.35-0.99
Suicide	5	0.30	0.10-0.71	13	1.09	0.56-1.90	21	0.64	0.40-0.98
Homicide	2	0.36	0.04-1.31	2	0.62	0.08-2.24	5	0.47	0.15-1.11

Table 3. Seattle, Portland, and Tacoma Firefighter Mortality Compared to Police From the Same Cities and Police Mortality compared to U.S. White Male Rates: 1945-1989

	Firefighters vs Police			Police vs U.S. White Males		
Cause of Death	**Deaths**	**IDR**	**95% CI**	**Deaths**	**SMR**	**95% CI**
All Causes	1168	0.87	0.79-0.95	710	0.87	0.81-0.93
All Cancers	291	0.97	0.80-1.17	169	0.95	0.81-1.11
Intestine	24	1.58	0.73-3.43	8	0.50	0.22-0.99
Rectum	7	0.72	0.23-2.30	5	1.11	0.36-2.59
Biliary Passages & Liver	6	0.71	0.19-2.71	4	1.40	0.38-3.59
Trachea, Bronchus, & Lung	93	0.94	0.67-1.33	55	0.92	0.69-1.19
Prostate	30	1.43	0.71-2.85	11	1.02	0.51-1.82
Skin	6	1.12	0.27-4.76	4	0.94	0.26-2.41
Brain and Nevous System	17	1.54	0.66-3.62	8	1.36	0.59-2.69
Lymphatic & Haematopoietic Cancers	37	1.03	0.62-1.73	21	1.22	0.75-1.86
Lymphosarcoma & Reticulosarcoma	7	0.81	0.30-2.22	5	1.72	0.56-1.02
Hodgkin's Disease	3	Inf.	_ _ _ _ _	0	0.00	0.00-1.87
Leukemia & Aleukemia	15	0.80	0.38-1.70	11	1.56	0.78-2.80
Other Lymphatic & Hematopoietic	12	1.40	0.48-4.07	5	0.93	0.30-2.17
Heart Diseases	461	0.86	0.74-1.00	269	0.85	0.75-0.96
Ischemic Heart Disease	394	0.88	0.74-1.01	223	0.86	0.75-0.98
Other Circulatory Disease	131	0.72	0.54-0.96	86	1.25	1.00-1.55
Cerebrovascular Disease	79	0.65	0.45-0.92	59	1.28	0.98-1.65
Arteries, Veins & Pulmonary Circulation	48	0.91	0.54-1.52	2.5	1.21	0.70-2.04
Respiratory Disease	81	1.11	0.71-1.73	30	0.64	0.43-0.91
Emphysema	20	1.45	0.54-3.88	5	0.63	0.20-1.46
COPD & Miscellaneous Lung Diseases	32	0.89	0.47-1.69	15	0.83	0.47-1.37

Table 4. Northwest U.S. Firefighter Mortality by Duration Of Exposed Employment 1945-1989

	< 10 Years			10-19 Years			20-29 Years			30+ Years		
Cause of Death	**Deaths**	**SMR**	**95% CI**	**Deaths**	**SMR**	**95% CI**	**Deaths**	**SMR**	**95% CI**	**Deaths**	**SMR**	**95% CI**
All Causes	128	0.73	0.6-0.9	180	0.85	0.7-1.0	527	0.78	0.7-0.9	334	0.93	0.8-1.0
All Cancers	34	0.97	0.7-1.4	46	1.07	0.8-1.4	142	0.91	0.8-1.1	68	0.95	0.7-1.2
Intestine	4	1.40	0.4-3.6	2	0.54	0.1-2.0	9	0.62	0.3-1.2	9	1.21	0.6-2.3
Rectum	1	1.35	0.1-7.5	0	0.00	0.0-3.4	5	1.19	0.4-2.8	1	0.42	0.1-2.3
Biliary Passages & Liver	0	0.00	0.0-7.3	0	0.00	0.0-5.5	3	1.15	0.2-3.4	3	2.31	0.5-6.7
Trachea, Bronchus, & Lung	11	0.96	0.5-1.7	13	0.93	0.5-1.6	56	1.04	0.8-1.4	13	0.63	0.3-1.1
Prostate	3	2.38	0.5-7.0	2	1.10	0.1-4.0	14	1.23	0.7-2.1	11	1.36	0.7-2.4
Skin	1	0.88	0.1-4.9	2	1.50	0.2-5.4	3	1.10	0.2-3.2	0	0.00	0.0-3.6
Brain and Nervous System	3	1.77	0.4-5.2	7	3.62	1.5-7.5	4	1.00	0.3-2.6	3	2.59	0.5-7.6
Lymphatic & Haematopoietic Cancers	4	0.88	0.2-2.3	7	1.43	0.6-3.0	14	1.06	0.6-1.8	12	2.05	1.1-3.6
Lymphosarcoma & Reticulosarcoma	1	1.33	0.1-7.4	1	1.09	0.1-6.1	3	1.32	0.3-3.9	2	1.95	0.2-7.1
Hodgkin’s Disease	1	1.13	0.1-6.3	1	1.39	0.1-7.7	1	1.08	0.1-6.0	0	0.00	0.0-11
Leukemia & Aleukemia	2	1.09	0.1-3.9	2	1.02	0.1-3.7	4	0.73	0.2-1.9	7	2.60	1.0-5.4
Other Lymphatic & Hematopoietic	0	0.0	0.0-3.4	3	2.31	0.5-6.8	6	1.33	0.5-2.9	3	1.69	0.4-4.9
Heart Disease	43	0.82	0.6-1.1	65	0.82	0.6-1.0	206	0.70	0.6-0.8	149	0.92	0.8-1.1
Ischemic Heart Disease	35	0.85	0.6-1.2	50	0.77	0.6-1.0	183	0.75	0.7-0.9	128	0.96	0.8-1.1
Other Circulatory Disease	9	0.96	0.4-1.8	11	0.74	0.4-1.3	52	0.80	0.6-1.1	59	1.24	0.9-1.6
Cerebrovascular Disease	5	0.84	0.3-2.0	6	0.61	0.2-1.3	35	0.80	0.6-1.1	33	0.99	0.7-1.4
Arteries, Veins & Pulmonary Circulation	4	1.32	0.4-3.4	4	0.93	0.3-2.4	15	0.79	0.4-1.3	25	1.99	1.3-2.9
Respiratory Disease	3	0.37	0.1-1.1	9	0.84	0.4-1.6	48	1.04	0.8-1.4	22	0.82	0.5-1.2
Emphysema	1	0.90	0.2-0.0	3	1.80	0.4-5.3	12	1.35	0.7-2.4	4	0.76	0.2-2.0
COPD & Miscellaneous Lung Diseases	1	0.31	0.1-1.7	3	0.81	0.2-2.4	20	1.14	0.7-1.8	9	1.07	05-2.0

Table 5. Seattle, Portland, and Tacoma Firefighter Mortality by Duration Of Exposed Employment Compared to Police From the Same Cities: 1945-1989

	< 10 Years			10-19 Years			20-29 Years			30+ Years		
Cause of Death	**Deaths**	**IDR**	**95% CI**	**Deaths**	**IDR**	**95% CI**	**Deaths**	**IDR**	**95% CI**	**Deaths**	**IDR**	**95% CI**
All Causes	125	0.94	0.8-1.2	179	1.06	0.9-1.3	527	0.78	0.7-0.9	334	0.88	0.8-1.0
All Cancers	34	1.01	0.7-15	46	1.22	0.9-1.7	142	0.89	0.7-1.1	68	0.86	0.6-1.2
Intestine	4	4.31	1.3-15	2	1.34	0.3-6.3	9	1.14	0.5-2.9	9	1.69	0.7-4.2
Rectum	1	1.21	0.1-12	0	0.00	-------	5	0.98	0.3-3.3	1	0.19	0.1-3.7
Biliary Passages & Liver	0	0.00	-------	0	0.00	------	3	0.52	0.1-2.9	3	1.90	0.5-6.9
Trachea. Bronchus. & Lung	11	1.05	0.6-2.0	13	1.17	0.6-2.2	56	1.01	0.7-1.5	13	0.57	0.3-1.1
Prostate	3	2.36	0.6-9.1	2	1.19	0.3-5.6	14	1.26	0.6-2.9	11	157	0.7-3.7
Skin	1	0.41	0.1-9.2	2	1.20	0.2-6.3	3	2.64	0.3-23	0	0.00	------
Brain and Nervous System	3	1.29	0.3-5.7	7	250	0.9-6.7	4	0.70	0.2-3.3	3	2.81	1.0-7.8
Lymphatic & Haematopoietic Cancers	4	0.66	0.2-2.5	7	1.15	0.5-2.9	14	0.75	0.4-1.5	12	1.14	0.5-2.6
Lymphosarcoma & Reticulosarcoma	1	1.17	0.1-39	1	0.54	0.0-5.1	3	0.74	0.2-2.6	2	0.44	0.1-2.2
Leukemia & Aleukemia	2	0.59	0.1-3.0	2	0.49	0.1-3.2	4	0.40	0.1-1.2	7	1.80	0.6-5.4
Other Lymphatic & Hematopoietic	0	0.00	------	3	2.98	0.8-12	6	1.25	0.4-4.4	3	1.13	0.2-8.3
Heart Disease	41	1.03	0.7-1.5	65	1.06	0.8-1.4	206	0.76	0.6-0.9	149	0.89	0.7-1.1
Ischemic Heart Disease	33	1.02	0.7-1.5	50	1.00	0.7-1.5	183	0.80	0.7-1.0	128	0.90	0.7-1.2
Other Circulatory Disease	9	0.88	0.4-1.9	11	0.60	0.3-1.1	52	0.53	0.4-0.8	59	0.99	0.7-1.5
Cerebrovascular Disease	5	0.79	0.3-2.1	6	0.51	0.2-1.2	35	0.51	0.3-0.8	33	0.82	0.5-1.3
Arteries, Veins & pulmonary Circulation	4	1.13	0.3-3.7	4	0.72	0.3-1.9	15	0.57	0.3-1.2	25	1.47	0.8-2.9
Respiratory Disease	3	0.64	0.2-2.2	8	1.40	0.6-3.1	48	1.22	0.8-2.0	22	1.07	0.6-2.1
Emphysema	1	2.46	0.2-30	3	3.34	0.9-13	12	1.59	0.6-4.6	4	0.69	0.2-3.0
COPD & Miscellaneous Lung Diseases	1	0.36	0.1-3.0	2	0.68	0.2-3.0	20	1.00	05-2.0	9	1.06	0.5-2.5

Table 6. Northwest U.S. Firefighter Mortality by Years Since First Employment 1945-1989

	< 20 Years			20-29 Years			30+ Years		
Cause of Death	Deaths	SMR	95% CI	Deaths	SMR	95% CI	Deaths	SMR	95% CI
All Causes	106	0.56	05-0.6	169	0.64	0.6-0.7	895	0.90	0.9-1.0
All Cancers	24	0.91	0.5-1.4	45	0.80	0.5-1.1	222	0.99	0.9-1.1
Intestine	1	0.51	0.1-2.9	3	0.66	0.1-1.9	20	0.91	0.6-1.4
Rectum	0	0.00	0.0-5.6	2	1.23	0.2-4.4	6	0.97	0.4-2.1
Biliary Passages & Liver	0	0.00	0.0-10	0	0.00	0.04.0	6	1.59	0.6-3.5
Trachea, Bronchus, & Lung	1	0.17	0.1-0.9	25	1.26	0.8-1.0	67	0.90	0.7-1.2
Prostate	0	0.00	0.0-2	0	0.00	0.0-3.0	30	1.42	1.0-2.0
Skin	2	1.41	0.2-5.1	1	0.71	0.14.0	3	0.88	0.2-2.6
Brain and Nervous System	5	2.36	0.8-5.5	1	0.43	0.1-2.4	11	2.53	1.3-45
Lymphatic & Haematopoietic Cancers	8	1.57	0.7-3.1	2	0.39	0.1-1.4	27	1.48	1.0-2.2
Lymphosarcoma & Reticulosarcoma	2	2.05	0.3-7.4	0	0.00	0.0-3.3	5	1.74	0.6-4.1
Hodgkin's Disease	2	1.53	0.2-5.5	1	1.63	0.1-9.1	0	0.00	0.0-3.8
Leukemia & Aleukemia	3	1.44	0.34.2	1	0.50	0.1-2.8	11	1.40	0.7-2.5
Other Lymphatic & Hematopoietic	1	1.41	0.1-7.9	0	0.00	0.0-2.6	11	1.69	0.8-3.0
Heart Disease	24	0.51	0.3-0.8	69	0.63	0.5-0.8	369	0.86	0.8-1.0
Ischemic Heart Disease	20	0.54	0.3-0.8	61	0.66	0.5-0.8	314	0.89	0.8-1.0
Other Circulatory Disease	3	0.37	.0.1-1.1	10	0.59	0.3-1.1	118	1.05	0.9-1.3
Cerebrovascular Disease	2	0.36	0.1-1.3	4	0.34	0.1-0.9	73	0.96	0.8-1.2
Arteries, Veins & Pulmonary Circulation	1	0.48	0.1-2.7	4	0.89	0.2-2.3	43	1.33	1.0-1.8
Respiratory Disease	3	0.50	0.1-1.5	8	0.72	0.3-1.4	71	0.95	0.7-1.2
Emphysema	0	0.00	0.0-7.2	0	0.00	0.0-1.8	20	1.39	0.9-2.2
COPD & Miscellaneous Lung Diseases	1	0.73	0.1-4.1	3	0.95	0.2-2.8	29	1.02	0.7-1.5

Table 7. Seattle, Portland, and Tacoma Firefighter Mortality by Years Since First Employment Compared to Police From the Same Cities: 1945-1989

	<20 Years			20-29 Years			30+ Years		
Cause of Death	Deaths	IDR	95% CI	Deaths	IDR	95% CI	Deaths	IDR	95% CI
All Causes	103	0.86	0.7-1.1	168	0.85	0.7-1.0	895	0.88	0.8-1.0
All Cancers	24	1.12	0.6-2.0	45	1.08	0.7-1.6	222	0.92	0.7-1.2
Intestine	1	2.00	0.1-115	3	3.58	0.7-2.5	20	1.52	0.7-3.3
Rectum	0	0.00	-------	2	3.12	0.3-35	5	0.48	0.1-1.8
Biliary Passages & Liver	0	0.00	-------	0	0.00	-----	6	1.02	0.3-3.8
Trachea, Bronchus & Lung	1	0.27	0.1-2.4	25	1.55	0.9-2.8	67	0.85	0.6-1.3
Prostate	0	0.00	------	0	0.00	-----	30	1.58	0.8-3.2
Skin	2	0.62	0.1-4.6	1	0.88	0.1-9.1	3	12.10.6->99	
Brain and Nervous System	5	1.10	0.34.3	1	0.39	0.1-4.3	11	3.04	1.0-9.6
Lymphatic & Haematopoietic Cancers	8	1.81	0.6-5.4	2	0.35	0.1-1.4	27	1.04	0.6-1.9
Lymphosarcoma & Reticulosarcoma	2	1.59	0.2-14	0	0.00	-------	5	0.77	0.2-2.5
Leukemia & Aleukemia	3	0.96	0.2-4.8	1	0.33	0.1-1.8	11	0.89	0.3-2.3
Other Lymphatic & Hematopoietic	1	3.85	0.343	0	0.00	-------	11	1.60	0.5-5.0
Heart Disease	22	0.71	0.4-1.3	69	0.87	0.6-1.2	370	0.89	0.8-1.1
Ischemic Heart Disease	18	0.77	0.4-1.4	61	0.96	0.7-1.4	315	0.88	0.7-1.1
Other Circulatory Disease	3	0.35	0.1-1.5	10	0.36	0.2-0.8	118	0.79	0.6-1.1
Cerebrovascular Disease	2	0.42	0.1-3.2	4	0.16	0.1-0.5	73	0.72	0.5-1.1
Arteries, Veins & Pulmonary Circulation	1	0.27	0.1-2.3	4	0.83	0.2-2.8	43	0.99	0.6-1.8
Respiratory Disease	3	3.24	0.4-24	7	1.25	0.5-3.3	71	1.08	0.7-1.7
Emphysema	0	0.00	-----	0	0.00	--------	20	1.48	0.6-3.9
COPD & Miscellaneous Lung Diseases	1	7.940.1->99		2	0.32	0.1-2.0	29	0.99	0..5-2.0

Table 8. Northwest U.S. Firefighter Mortality by Age at Risk 1945-1989

	18-39 Years Old			40-64 Years Old			65+ Years Old		
Cause of Death	**Deaths**	**SMR**	**95% CI**	**Deaths**	**SMR**	**95% CI**	**Deaths**	**SMR**	**95% CI**
All Causes	56	0.57	0.4-0.7	458	0.69	0.6-0.8	656	0.97	0.9-1.1
All Cancers	15	1.40	0.8-2.3	123	0.81	0.7-1.0	153	1.07	0.9-1.3
Intestine	1	1.38	0.1-7.7	10	0.78	0.4-1.4	13	0.86	05-15
Rectum	0	0.00	0.0-0.2	3	0.73	0.2-2.1	5	1.22	0.4-2.8
Biliary Passages & Liver	0	0.00	0.0-0.3	1	0.40	0.1-2.3	5	2.02	0.7-4.7
Trachea, Bronchus, & Lung	0	0.00	0.0-2.8	46	0.83	0.6-1.1	47	1.09	0.8-1.5
Prostate	0	0.00	0.0-1.7	4	0.85	0.2-2.2	26	1.46	1.0-2.1
Skin	1	1.27	0.1-7.1	4	1.14	0.3-2.9	1	052	0.1-2.9
Brain and Nervous System	4	3.52	1.0-9.0	8	1.42	0.6-2.8	5	2.47	0.8-5.8
Lymphatic & Haematopoietic Cancers	5	1.69	0.6-3.9	13	0.95	0.5-1.6	19	1.61	1.0-2.5
Lymphosarcoma & Reticulosarcoma	2	3.92	0.5-14	2	0.74	0.1-2.7	3	1.72	0.4-5.0
Hodgkin's Disease	2	2.17	0.3-7.9	1	0.70	0.1-3.9	0	0.00	0.0-7.0
Leukemia & Aleukemia	1	0.80	0.1-4.5	5	0.94	0.3-2.2	9	1.67	0.8-3.2
Other Lymphatic & Hematopoietic	0	0.00	0.0-13	5	1.19	0.4-2.8	7	1.67	0.7-3.5
Heart Diseases	11	0.76	0.4-1.4	183	0.67	0.6-0.8	269	0.90	0.8-1.0
Ischemic Heart Disease	9	0.92	0.4-1.7	157	0.69	0.6-0.8	230	0.94	0.8-1.1
Other Circulatory Disease	2	0.60	0.1-2.2	30	0.68	0.5-1.0	99	1.10	0.9-1.3
Cerebrovascular Disease	1	0.44	0.1-25	21	0.71	0.4-1.1	57	0.92	0.7-1.2
Arteries, Veins & Pulmonary Circulation	1	1.17	0.1-6.5	7	0.55	0.2-1.1	40	1.57	1.1-2.1
Respiratory Disease	1	0.37	0.1-2.1	15	0.45	0.2-0.8	67	1.16	0.9-1.5
Emphysema	0	0.00	0.0-0.4	3	0.50	0.1-1.5	17	1.57	0.9-2.5
COPD & Miscellaneous Lung Diseases	1	1.72	0.1-9.6	4	0.36	0.1-0.9	28	1.31	0.9-1.9

Table 9. Seattle, Portland, and Tacoma Firefighter Mortality by Age at Risk Compared to Police From the Same Cities: 1945-1989

	18-39 Years Old			40-64 Years Old			65+ Years Old		
Cause of Death	**Deaths**	**IDR**	**95% CI**	**Deaths**	**IDR**	**95% CI**	**Deaths**	**IDR**	**95% CI**
All Causes	55	0.87	0.6-1.3	455	0.80	0.7-0.9	656	0.94	0.8-1.1
All Cancers	15	1.51	0.7-3.5	123	0.90	0.7-1.2	153	0.99	0.7-1.3
Intestine	1	Inf.	-------	10	1.71	0.5-5.5	13	1.32	0.5-3.8
Rectum	0	---	------	3	1.97	0.2-18	4	0.43	0.1-1.8
Biliary Passages & Liver	0	---	------	1	0.25	0.1-1.9	5	1.77	0.2-1.3
Trachea, Bronchus, & Lung	0	0.00	-------	46	0.91	0.6-1.4	47	1.03	0.6-1.8
Prostate	0	---	-------	4	0.55	0.1-2.4	26	1.88	0.8-4.2
Skin	1	0.74	0.1-19	4	1.05	0.2-5.6	1	Inf.	-------
Brain and Nervous System	4	1.25	0.3-5.7	8	1.53	0.5-4.9	5	2.33	0.3-2.1
Lymphatic & Haematopoietic Cancers	5	3.24	0.6-19	13	0.59	0.3-1.2	19	1.62	0.7-1.3
Lymphosarcoma & Reticulosarcorna	2	Inf.	-------	2	0.60	0.1-4.9	3	0.51	0.2-1.8
Leukemia & Aleukemia	1	0.60	0.1-6.7	5	0.40	0.1-1.1	9	3.52	0.7-1.7
Other Lymphatic & Hematopoietic	0	---	-------	5	0.89	0.2-3.5	7	2.89	0.5-1.8
Heart Diseases	11	1.32	0.5-3.8	181	0.78	0.6-1.0	269	0.92	0.7-1.1
Ischemic Heart Disease	9	1.27	0.4-4.0	155	0.83	0.7-1.1	230	0.90	0.7-1.1
Other Circulatory Disease	2	Inf.	-------	30	0.41	0.3-0.7	99	0.94	0.7-1.4
Cerebrovascular Disease	1	Inf.	-------	21	0.41	0.2-0.7	57	0.82	05-1.3
Arteries, Veins & Pulmonary Circulation	1	Inf.	-------	7	0.40	0.2-1.0	40	1.25	0.7-2.4
Respiratory Disease	1	Inf.	-------	13	0.69	0.3-1.6	67	1.27	0.8-2.2
Emphysema	0	---	-------	3	159	0.2-16	17	1.42	0542
COPD & Miscellaneous Lung Diseases	1	Inf.	-------	3	0.25	0.1-1.1	28	1.16	0.6-25

Discussion

As anticipated, many of the results of this study are consistent with the “healthy worker effect.” The risks of dying from non-malignant diseases of the heart, respiratory system, digestive system, nervous system, and diabetes were all less than expected compared to U.S. white male rates and the risk for most non-malignant diseases appears to generally increase with years since first employment and age. Firefighters were also at less risk of cardiovascular disease than police. One exception was deaths due to diseases of the arteries, veins and pulmonary circulation which was elevated among firefighters with at least 30 years of exposed employment relative to both U.S. white males rates and police.

In analyses of this cohort performed with follow-up through 1983 we found an excess of non-malignant respiratory disease relative to police (IDR = 1.59) as opposed to a deficit when compared to U.S. rates (SMR = 0.88)(48). Based on those results we concluded that an excess may have been obscured in other studies because of the use of general population rates. One dollar study which compared lung disease deaths in firefighters to police officers found a similar result (7). Although this disparity was also found in the current analysis, the magnitude was greatly reduced. This may be in part be accounted for by the increasing availability and use of respiratory protection since the 1970's. In addition. the risk of death due to non-malignant respiratory disease among police was higher in the current (SMR = 0.64) than in the earlier analysis (SMR = 0.48).

This study did find an elevated risk of emphysema, one form of non-malignant lung disease, among firefighters relative to both U.S. white males and police. All of these deaths occurred among individuals at least 30 years after first employment but was highest among those with 10 to 29 years of exposed employment. If a relationship does exist between exposure to smoke and emphysema, the fact that the risk was reduced among firefighters with 30 or more years of exposed employment might be due to those most susceptible to disease being forced to leave employment early due to disability. Attempts to draw conclusions should be tempered by the fact that the specificity of death certificates is low with regards to differentiating between different types of obstructive lung diseases and the risks observed for COPD although similar were of lesser magnitude.

Perhaps the strongest finding of this study is that of an excess of brain cancer among firefighters with 30 or more years since first employment employment to both U.S. white males and police. Other studies have also observed an excess of this malignancy (3-5,12,15,17). The etiology of brain cancer is not well understood but workers exposed to vinyl chloride, acrylonitrile, and polycyclic aromatic hydrocarbons have been noted to be at higher risk (54). Although is difficult to quantify, it is likely that exposure to polycyclic aromatic hydrocarbons at fires is common while exposure to vinyl chloride and acrylonitrile may happen only under certain conditions. If the excess of brain cancer were due to exposures that were not necessarily present at most fires, this might in part explain the lack of association with simple duration of exposed employment.

This study also found an excess risk of lymphatic and hematopoietic cancers, particularly of leukemia, among individuals employed for 30 or more years in fire combat positions. This confirmed our earlier observation of an increased risk among Seattle firefighters. Other studies have also observed an excess of lymphatic and hematopoietic cancers of various histologies (4,7,12,13, 16,17) and an excess of these types of malignancies is plausible given the exposure to benzene seen exposure assessment assessment studies (20,21). Although benzene exposure is likely short-term, measurements in excess of 100 ppm have been taken (20,21). Our ability to draw conclusions is tempered by our observation of an excess in police. At question in judging the validity of the firefighter excess is whether the excess in police is due to factors held in common between the two occupational groups or due to some exposure unique to police. It this point we have inadequate information to answer this question, however, two other studies which have examined leukemia in firefighters versus police found firefighters to be at higher risk.

This study did not find much evidence to support and excess of cancers of the colon, rectum, skin. bladder, or lung in firefighters which have been observed in some other studies. The inconsistency with previous studies may be due to the small number of deaths observed for some sites or to the different methods used and varying time periods examined by previous studies. The excess of prostate cancer has not been observed in other studies and the prostate is not generally regarded as a site for occupational cancer.

There are a number of limitations that should be borne in mind when interpreting the results of this study. First, duration of fire combat employment, although an improvement over total duration of employment, may still be an inadequate measure of exposure, particularly for substances that may not be present at all fires. Exposure may vary substantially between fires and different areas around the same fire due to not only the composition of the material being burned but also the temperature of the fire and availability of oxygen (20,22). Thus, the lack of association seen between duration or fire combat employment and various outcomes in this study may in part be due to the use of a poor surrogate for exposure.

Two other studies of firefighters have used police as a reference population (7,16). Police were chosen because they have similar socioeconomic status, health benefits, and strict physical entry requirements, and are generally free from any major fire smoke inhalation. In addition, two studies of smoking habits by occupation show that police and fire fighters are relatively similar (55,56), although a somewhat greater percentage of fire fighters reported having never smoked. However, this approach does suffer from a number of limitations. Because of the small size of the reference population, the IDR's lack statistical stability and the confidence limits are correspondingly wide. In addition, police have rarely been studied and their occupational exposures and risks for death due to various causes have not been well characterized. An excess or deficit in police due to their own unique exposures or characteristics which may cause their rates to diverge from an appropriate standard could lead to spurious conclusions about firefighters. Potential police exposures include carbon monoxide, polycyclic aromatic hydrocarbons, lead, solvents, and electromagnetic radiation. The magnitude and health effects of these exposures are not known and their potential for introducing bias should be borne in mind.

Another limitation of this study is the lack of accuracy and specificity of cause of death information on death certificates. In the case of heart and lung disease it may be difficult to assign a specific cause of death without an autopsy. Cancer information on death certificates suffers from a lack of detail and only rarely includes anatomical sub-site or histologic information. Specific histologic information would be particularly informative for the brain cancers and leukemias observed in this study. While some exposures might increase the risk of neoplasms of multiple histologies or multiple types of lung or heart diseases, this should not be assumed. To the extent that a cause of death category contains a wide range of etiologically unrelated diseases, the relationship between the exposure and any one specific disease will be obscured.

In conclusion, this study found an excess of brain cancer and leukemia among city firefighters from the Northwest United States. Our results also suggest that firefighters may be at excess risk of emphysema and diseases of the arteries, veins and pulmonary circulation. These areas deserve further exploration. We are currently examining the incidence of cancer in this population using a regional tumor registry and further analyses of cardiovascular and respiratory diseases are planned using poisson regression.

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